United States Department Of Agriculture | Forest Service | Shasta-Trinity National Forests

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Subject: Biological Evaluation of Bark Beetles and Dwarf Mistletoe in the Hermit Fire

To: Forest Supervisor, Shasta-Trinity National Forests

The Hermit Fire occurred in early October, 1988 on the Yolla Bolla R.D. Various portions of the burn were examined by Dave Schultz, entomologist, Gregg DeNitto, plant pathologist, and Jeff Paulo, acting District Silviculturist, on 11/2/88 and 11/9/88. The burn totals about 7,500 acres with 2,500 acres within the Yolla Bolly Middle Eel Wilderness. Much of the accessible portion of the burn lies within the watershed of the South Fork of the Trinity River in T. 27 N., R. 11 W. MDM. Elevations in the non-wilderness portions of the burn range from about 3,200 ft. to 7,200 ft. The terrain is generally steep, with slopes of 50%, or more, being common. Site quality varies from extremely high to non-commercial over fairly short distances. Most stands would generally be considered to be mixed conifer with either ponderosa pine or Douglas-fir predominating. Other common conifers include sugar pine and incense-cedar. White fir becomes common at the upper elevations. Some areas had several distinct layers in the stand, with the predominants showing old scars from previous fires. Common hardwoods include California black oak, canyon live oak,, Oregon white oak, madrone and bigleaf maple.

The burn had a mosaic of fire intensities ranging from a fairly light underburn to areas hot enough to consume all of the foliage and smaller branches from the trees. Areas where all aerial portions of the vegetation had been killed were common.

Native conifer diseases include Douglas-fir dwarf mistletoe, Arceuthobium douglasii, which infects Douglas-fir, and western dwarf mistletoe, A.campylopodum, which infects ponderosa, Jeffrey, and knobcone pines. The normal role of dwarf mistletoes is to reduce annual growth and vigor of the host. Although it is rare for dwarf mistletoe to kill a tree by itself, a substantial proportion of trees which die during drought periods have been previously stressed by moderate to severe dwarf mistletoe infections. Dwarf mistletoes are perpetuated when infected overstory trees remain to infect the regeneration after a stand is partially removed by fire or harvest.

An introduced disease common in the area is white pine blister rust, Cronartium ribicola. It has a complex life cycle which involves alternate hosts, five-needle pines and Ribes spp. (currants and gooseberries). The major host of concern in the Region is sugar pine. The fungus forms a canker on branches and boles, causing tree mortality.

The burn eliminated many of the hosts of blister rust in the drainage. Because Ribes seeds are stimulated to germinate by disturbance, it should increase in abundance very quickly. Increased numbers of Ribes can cause an increase in the level of disease, especially if non-resistant sugar pines are planted.

A number of common bark and engraver beetle and borers are usually present at low numbers in the South Fork drainage, these include:

Common Name	Scientific Name	Host
Douglas-fir engraver	*Scolytus unispinosus*	Douglas-fir
Fir flatheaded borer	*Melanaphila drummondi*	Douglas-fir, true firs
Western pine beetle	*Dendroctonus brevicomis*	Ponderosa pine
Pine engraver beetles	*Ips* spp.	All pines
California flatheaded borer	*Melanophila californica*	All pines
Mountain pine beetle	*Dendroctonus ponderosae*	Sugar pine (also ponderosa, lodgepole and western white)
Red turpentine beetle	*Dendroctonus valens*	All pines
Fir engraver	*Scolytus ventralis*	Red and white fir

These beetles are able to maintain populations in an area in trees which are severely suppressed, struck by lightning, diseased, injured by soil movement, fire scorch, fluctuating water table, or other type of disturbance. The Douglas-fir engraver and pine engravers are capable of breeding in green host material which has been cut or broken from a tree. All of these beetles have some potential to build up in an area if large numbers of trees have been made susceptible by a widespread environmental factor such as drought or fire scorch. There is usually limited movement of beetles into or out of a given area, but instead, the resident population will build in place in response to increased habitat (stressed trees) and decrease after the available habitat has been exploited.

Most of the trees in the South Fork drainage have been subject to some level of drought stress for the past two years. In addition, growth rings of some of the predominant trees indicate they have been growing at a rate of 40-50 rings per inch for the past 80-100 years. The combination of drought, age, diseases such as dwarf mistletoe, and heavy stocking levels have resulted in an increase in conifer mortality over the past two years.

Although the Hermit Fire probably killed some beetles when it burned the infested hosts, there appears to be an adequate supply of beetles left to occupy many of the trees most severely stressed by fire injury and/or other factors.

By November 9, 1988, there were already signs that some fire injured ponderosa and sugar pines were being attacked by mountain pine beetle and red turpentine

beetle. Because the burn occurred fairly late in the year, it is unlikely there will be many more beetle attacks prior to March, 1989. Some of the most severely fire-injured trees may die during the winter, without ever being exposed to bark beetle attack.

Fire-injured trees which are still alive in the spring of 1989 can be rated for their probability of survival. Table 1 gives the maximum amounts of crown and cambial damage acceptable for leave trees that were fairly vigorous and growing on good sites prior to being burned. The probability of beetle attack will increase with the number of other stress factors affecting the trees. Factors which could be important include low site, extreme old age, moderate to severe levels of dwarf mistletoe infection, stocking levels approaching or above normal basal area and sudden recent exposure, such as isolated trees or along edges of severely burned areas. Research has shown that under the best of conditions, trees which exceed the amount of fire-injury shown in Table 1 can be considered "dead" and that even less fire-injury should be considered life-threatening if another factor lowers the tree's vigor.

Depending upon the tree species, tree size and species of beetle involved, dead trees may fade as early as 1989 or as late as 1993.

Management Alternatives

1. No Action. This alternative would do nothing in the area. No timber harvest, roading, or recovery projects would be done. The area would be left as is.

The probable course of events if no action is taken in the drainage can be portayed in a qualitative way. In the severely burned areas, scattered hardwood trees and brush will sprout from root crowns. Where these develop from well established root systems, the plants will have a competitive advantage over vegetation that develops from seed. Some forbs and grass will germinate in places. There are some isolated living (but injured) trees within some severely burned areas. If they live, some of these trees will produce an abundant crop of cones in response to stress. This may result in some restocking of conifers in the area, although the prospects will diminish rapidly with the passage of time. The bare mineral seedbed which existed shortly after the burn has already been covered with a layer of fallen leaves and needles, competing vegetation is starting to develop in spots, and some of the potential seed trees have a high probability of dying before the cones can fully ripen. A few isolated trees or stringers may survive for decades, but most should be expected to die within the next few years. The greatest chances of survival would be at the highest elevations, on north slopes and along ephemeral or permanent water courses. If the trees are infected with dwarf mistletoe and survive longer than about 10 years, they can also provide an infection source to susceptible tree species which seed in near them.

Scattered mortality over the next few years should also be expected along the edges of severely burned areas. For a distance of 50 to 100 feet inside the living stand, the growing conditions for trees have often been altered by various combinations of cambial damage, crown scorch, change in root environment by consumption of duff, root killing or injury by heat, change in amount of radiant energy and evapotranspiration after stand opening, and sunscald.

Depending upon the distance from a suitable seed source and seedbed conditons, some severely burned areas may have immature stands of timber in as little as 60 years, while other areas are still brushfields waiting for a seed source to "leapfrog" close enough to be of use.

The moderately burned areas are a mosaic of small patches of severely burned areas and small patches of fire-injured trees. This produces a very large area of "edge effect", which should result in extensive, scattered mortality prolonged over a period of years. A disproportionate amount of hardwoods and brush will probably survive because of diferences in the nature of the beetles which attack broadleaf plants and conifers, as well as the ability of many woody broadleaf plants to sprout. Some conifers may seed in, but large numbers should not be anticipated in the moderately injured areas. The openings produced by the severely burned pockets are fairly small at this time. Although an excellent seedbed existed shortly after the fire, shade from the surrounding live trees, as well as competition for moisture may limit the survival of any conifers that seed in. The openings will gradually enlarge over the next few years but conditions for conifer seed germination will deteriorate rapidly. After conditions stabilize, there should be some scattered individuals and small groups of conifers left alive.

In the lightly burned areas some scattered trees were killed directly by the fire. Additional trees were nearly or completely girdled at the base and will fade as the weather warms. Some scattered trees were also injured severely enough that they will be very susceptible to attack by bark beetles or flatheaded borers. Most of these attacks will result in the loss of single trees. A possible exception would be areas which are predominantly ponderosa pine. If a weakened pine is successfully attacked by western pine beetle, the successful beetles will release a pheromone which will attract other westerrn pine beetles to the area. Other ponderosa pine within about 20 feet may also come under attack and result in a group kill of several to 30 or more trees. The size of a group kill will depend on the number of beetles attracted, proximity of ponderosa pine to the initial tree under attack, other tree species or natural features that break up a stand, general vigor of the stand and probably other unknown factors.

The net effect in the lightly burned areas should probably be neutral. The scattered mortality and small groups of trees killed should reduce competition and eventually increase growth and vigor among the survivors. On the other hand, many of the living trees have been wounded to one degree of another by basal scorching and may take years to fully recover. The situation should stabilize in a few years and the lightly burned areas should be in reasonably good health for unmanaged stands. Within a few decades, the effects of increasing basal area, increasing dwarf mistletoe infections and increasing tree age will all tend to decrease growth and vigor.

Dead trees left standing after a burn will deteriorate at a predictable rate. Table 2 and Figure 1 were derived from the expected rate of deterioration of four conifer species. Table 2 gives the minimum dbh of trees which will meet 25% or 33% utilization standards and also have a sound core at least 6 inches diameter. When using Table 2, there are some points to consider:

1. The time frame started with the fire. Therefore, information on Year 1 is applicable until October, 1989.

2. Some stems smaller than those listed in Table 2 will still technically have over 25% sound material (see Figure 1). The diameters in Table 2 were truncated at the point where the sound wood reached 6 inches because a cylinder of 5.7 inches is the smallest diameter that will encompass a 4 x 4 inch cant. If biomass or fiber are included in the intended mix of the products, either smaller diameters can be considered salvageable, or larger diameters will be salvageable for a longer period of time.

3. The information in Table 2 and Figure 1 is based on some broad averages. Specific conditions which can vary widely within a single drainage may retard or advance the rate of deterioration:

A. High elevation sites and dry sites tend to retard the rate of deterioration by insects and fungi. Moist sites and warm temperatures increase the rate of deterioration. Aspect may be important.

B. Tree species and size influence the rate of deterioration, but age and growth rate are also important. Old growth timber often has considerable heartwood, which is more resistant to decay, as well as narrow growth rings which also increase the resistance. Young trees tend to have a lot of sapwood, and fast-growing trees have wide rings which makes them less resistant to decay.

C. The base of a fire-killed tree is generally more moist than the rest of the tree and deterioration will be most rapid at that point. At 3 to 5 years after the burn (1991 - 1993) the severely burned stands will begin to break apart. This may affect attempts to salvage material after that point. Standing trees which are weak at the base may affect worker safety and jack-strawed trees on the ground may be difficult to retrieve or may limit access.

2. Recovery Projects. This alternative would only consider recovery projects for the area. Erosion control structures, sediment traps, revegetation, maintenance/enhancement of fisheries habitat and maintenence/enhancement of water quality would be the key factors.

In the lightly burned areas there would probably be few projects that would affect the vegetation and the prognosis would remain the same as the No Action alternative. In the moderately and severely burned areas the activity that has the greatest potential to alter the outcome is revegetation. If the vegetation which is seeded or planted consists of native trees, the timetable for the prognosis portrayed for Alternative 1 would be speeded. If the revegetation consisted largely of seeding native or exotic grasses, the time table would be delayed because the grass will initially out-compete tree seedlings for moisture and later will prevent conifer seed germination.

3. Salvage Only Dead Trees. This alternative would only allow timber harvest of fire killed timber; no green timber would be considered. Mitigation may include KV and other recovery projects identified in alternative 2.

Lightly burned areas would probably not be entered, or only marginally impacted, so the outcome would be the same as Alternative 1. If there are any scattered green trees left in severely burned areas after the fire-killed timber is

salvaged, a large proportion of them should be expected to die over a period of several years. Mortality will not be quite as severe around the edges of the severely burned areas or within the moderately burned areas, but will still be substantial and occur over a protracted time period. Removal of the fire-killed timber would probably cause some soil disturbance which has the potential to expose a suitable seedbed for conifers. Some of the surrounding green timber which could provide seed may also provide a source of dwarf mistletoe to infect developing conifer seedlings.

This scenario is based on the assumption that salvage will include both the black trees, as well as the "green dead". If the salvage does not include green trees which have fire-caused injuries more severe than those listed in Table 1, the amount of mortality should be approximately the same as with Alternative 1.

4. Regeneration/Salvage. This alternative provides for the harvest of fire-killed timber and the harvest of green timber associated with those stands of dead timber. No all green stands of timber would be harvested. Primary focus here is to leave healthy stands of timber or plantations. Mitigation may include KV funded projects as well as recovery projects identified in alternative 2.

This is a variant of alternative 3 which additionally removes some associated green trees to produce logical units. It should convert the severely burned areas which are accessible into plantations. The moderately burned areas which are accessible will probably either be cleared for plantations or become shelterwoods. Assuming that green trees left standing within or adjacent to the new plantations do not have dwarf mistletoe, and that site preparation is adequate, the resulting plantations should be fairly healthy.

5. Use specific management activities to reduce impacts of insects and diseases.

Some of the techniques listed below may be appropriate to achieve management goals under a specific set of circumstances. None should be considered a blanket prescription for the area.

1. Drop surplus dead trees before regenerating sites. Dead trees will eventually decay and fall. Trees over 10 inches dbh have the potential to break seedlings or saplings, or open entry courts for decay fungi by damaging bark as they fall. Dead trees over 10 inches dbh not needed for wildlife or other purposes should be dropped or otherwise removed before sites are regenerated.

2. Plant appropriate mixture of seedling stock. Many future problems can be avoided by planting stock from the appropriate seed zone and elevation. Some insects and diseases are host specific. Planting a mixture of species appropriate to the site will retard the spread of some organisms and will limit the magnitude of some others.

3. Examine leave trees for presence of dwarf mistletoes. Presence of dwarf mistletoes should be included in marking guides prepared for identification of high risk trees in burned areas. They add to other stress factors in increasing the risk of tree mortality. Trees with dwarf mistletoe ratings of 5 or 6 have a higher probability of mortality even under normal conditions, and increase the probability of mortality of trees with fire injury. Borderline trees with a

rating of 4 should also be removed because of increased probability of mortality, unless there are other management objectives that require their retention.

Dwarf mistletoes in overstory leave trees can infect planted or natural understory trees that are susceptible to the species of dwarf mistletoe. As long as infected overstory trees remain, the understory will be impacted as new infections occur throughout the trees. This will retard growth and increase susceptibility to mortality. Heavily infected trees (mistletoe ratings of 5 and 6) may produce 30-60% less timber volume than uninfected individuals.

In some areas, it may be desired to release an understory which was lightly burned. Infected overstory trees would be removed and dense agregates in the understory would be thinned. Thinning criteria should include the level of dwarf mistletoe infection. Trees with infections in the upper third of the crown should be removed. Most light to moderately infected trees which are free to grow and do not have an overstory source of infection can outgrow dwarf mistletoe infections, at least on the better sites.

Dwarf mistletoes tend to be host specific. If it is desirable to plant seedlings of the same species in an area with an infected overstory, it would be simplest to drop or remove infected overstory trees prior to planting. If infected overstory trees need to be retained for other objectives, there are several alternatives to produce relatively healthy regeneration:

A. Do not plant the susceptible host. If a non-host is regenerated, then infections will not occur.

B. If only a few infected overstory trees occur in the stand, plant non-hosts within 100-150 feet of infected overstory trees, and susceptible host trees further away.

C. Plant an appropriate species mix, and plan to eliminate infected overstory within 10 years. The infected overstory can be temporarily used as a seed source for natural regeneration or as shade until planted trees become established. During the first 10 years, the regeneration presents a small target and is not likely to become infected. As it becomes larger, it is more likely to have mistletoe seeds land on it and infect it. The overstory infection may be eliminated by harvesting, dropping or girdling the overstory. If harvesting is planned, early removal will cause less damage to the regeneration. Girdling will eventually kill trees, although it may take as long as four years for the trees to die. Girdled conifers usually die because they are attacked by bark beetles. While there is no danger of starting an outbreak in this way, it should be understood that this technique is somewhat non-selective. Because the beetles attacking the girdled tree will release an aggregating pheromone to draw additional beetles into the area, other mature host trees within 20-30 feet from the tree under attack will also be at risk even if they have not been girdled.

D. Consider the presence of dwarf mistletoe when setting unit boundaries. Uninfected stands, non-host stands, roads, streams and rock outcrops can all be used as buffers to prevent the reintroduction of dwarf mistletoe into the newly regenerated area. Non-hosts can be planted along boundaries where it is impossible to take advantage of existing buffers. Buffer size depends on slope and prevailing winds, but a general rule is that they should be at least as wide as the highest infection in the trees.

4. Plant blister rust resistant sugar pine. Average collections of sugar pine seed from the South Fork area would probably show about 1-1.5% resistance to blister rust. While there may be some low level of natural resistance and some other trees might escape infection long enough to produce commercial size trees, planting more than 10% sugar pine from a wild seed collection could jeopardize stocking levels in the plantations. If blister rust resistant sugar pine seed from that seed zone is available, it would be a good candidate to use in planting mixtures on appropriate sites.

5. Treat green pine slash. If pines with some green foliage are cut, the slash from about 3 to 10 inches diameter could be used as breeding material by pine engravers. The major threat would be to living pines located within about 1/4 mile which are also desireable to retain. Assuming there is some resource in the area to protect, the most feasible method of modifying green pine slash in a timber sale is to lop all blanches and buck the boles and large stems into the shortest pieces possible. If the stem and branch pieces are placed flat on the ground in full sunlight, the top of the pieces becomes too warm for pine engraver breeding and the part in contact with the soil will go sour. It is also possible to burn the slash, however, during the warm parts of the year pine engravers may complete their life cycle in less than 2 months. They may emerge before the slash is fully dry and fire restrictions may prevent burning before they emerge.

6. Protect high value pines. Under certain circumstances the value of an individual tree may be quite high if it remains living. Examples include known nest or roost trees of key wildlife species, identified genetically superior trees, seed trees of a source in short supply, historical trees or trees with a high recreational or aesthetic value. If a high value pine has a temporary, reversible stress such as fire scorch or drought, it can be protected from attack by bark beetles for a period of up to a year by a single application of a registered insecticide (such as CHIPCO SEVIMOL brand Carbaryl insecticide, EPA Reg. No. 264-321) to the lower 30-35 feet of the bole. Because the application is usually done with a truck-mounted hydraulic sprayer, this technique is normally limited to situations within 200-300 feet from established roads. There are ways of treating more remote trees if the added cost and labor are warranted. If reasonable care is used during application and mitigating techniques such as tarps around the tree base to intercept insecticide splash are used, the treatment will have little environmental impact.

If you need additional input on this subject, please contact either Dave Schultz or Gregg DeNitto directly at 916-246-5087.

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Table 1. Minimum Survival Criteria For Burned Trees

Species	Cambial Injury[1]	Green Foliage
Douglas-fir	25 % maximum	min.: 35 % original crown
white fir	25 % maximum	min.: 35 % original crown
incense-cedar	25 % maximum	min.: 35 % original crown
sugar pine	60 % maximum[2]	min.: 35 % original crown
ponderosa pine	25 % maximum	min.: 0 % original crown[3]

Notes:

1. Cambial injury refers to percent of circumference killed. Any injury higher than normal stump height is considered "severe" and reduces chances of survival.

2. Check sugar pine with basal scorch carefully at ground line. Thin bark can lead to cambial kill with only "minor" outward charring.

3. Many PP with less than 10% green foliage will survive, but min. of 10-20% is preferable. Must have at least 50% live buds in crown.

Extracted from: Wagener, W. W., 1961. Guidelines for estimating the survival of fire-damaged trees in California. U.S. Forest Serv. Pacific Southwest Forest and Range Expt. Sta. Misc. Paper 60. 11pp.

Table 2.

MINIMUM DBH OF SALVABLE MATERIAL AFTER BURNS

Extracted from: Kimmey, J. W. 1955. Rate of deterioration of fire-killed timber in California, Circular No. 962, USDA. 22p.

A. Minimum 25% gross board foot volume, 6 inch sound core.

	Species	White fir	Douglas-fir	Sugar pine	Ponderosa pine
		dbh	dbh	dbh	dbh
	1	10+inches	10+inches	10+inches	10+inches
	2	22	16	16	22
	3	26	16	18	36
YEARS	4	38	16	20	44
AFTER	5	N/A	16	20	60
BURN	6		18	22	N/A
	7		18	24	
	8		18	26	
	9		18	28	
	10		18	30	

B. Minimum 33% gross board foot volume, 6 inch sound core.

	Species	White fir	Douglas-fir	Sugar pine	Ponderosa pine
		dbh	dbh	dbh	dbh
	1	10+inches	10+inches	10+inches	10+inches
	2	26	16	16	32
	3	34	16	20	46
YEAR	4	N/A	16	24	60
AFTER	5		16	26	N/A
BURN	6		18	30	
	7		18	34	
	8		18	40	
	9		18	46	
	10		20	60	